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VII.

SPECIMENS OF MILK FROM THE VICINITY OF BOSTON.

By S. P. Sharples, S.B.

Presented, Dec. 14, 1875.

In 1873, Dr. Arthur H. Nichols of this city made a report to the State Board of Health in regard to adulteration of milk. In this report, certain analyses of milk made by Prof. J. F. Babcock were quoted: these specimens were seven in number, and of the following average composition: —

Specific gravity	1.033
Cream volume, per cent	8 to 9
Total solids, weight per cent	14.55
Sugar, weight per cent	5.08
Ash	.86
Water	85.45

These samples were not selected, but were bought from regular dealers who were known to be honest. In view of the fact that the 14.55 is much above the average amount of solids as given by most European chemists, it becomes a matter of interest to ascertain if the milk produced in this vicinity is better than the average, or whether this was a mere accidental occurrence.

During the last summer I had an opportunity of procuring from Stoneham some twenty specimens of milk. These were brought to me by my assistant, Arthur Steele, who was present during the milking of the cows, and who asserts they were not tampered with in any manner. The milk was produced by cows belonging to different owners, the owner's name in each case being given in connection with the description of the cow.

The method of analysis was as follows: —

For specific gravity one hundred cubic centimetres of the milk were poured into a flask that held this amount of water at 15 °5 C., the temperature was observed by the thermometer, and the milk was cooled or warmed until it stood at 15 °5; it was then weighed. This same portion of milk was placed in a graduated cylinder, and allowed to stand in a cool place until next morning, when the amount of cream was read off. A pipette was then introduced into the cylinder in such a manner that it reached to the bottom of the vessel, and fifty centimetres were drawn off; this was weighed, and gave the specific gravity of the skim milk. After weighing, the milk was poured into a beaker, one or two drops of acetic acid added, the milk gently warmed until it coagulated, and then allowed to cool again. It was then thrown on a filter, and the first fifty centimetres that ran through were weighed as before: this gave the specific gravity of the whey.

These two last determinations were made because many authors assert that the specific gravity of skim milk and whey are much more constant than the specific gravity of whole milk.

Von Baumhauer asserts in his monograph on Dutch cow's milk that he has been unable to obtain clear filtrates when the curd was precipitated with acetic acid. I have rarely found any difficulty on this score, when the precaution of heating the milk only a little hotter than from 40° to 50° C. was taken, provided the milk was allowed to become cold before it was filtered. If the milk is allowed to cool completely after coagulation, before it is filtered, it generally filters without any trouble; but, if poured on the filter before it becomes cold, the fat fills the pores of the filter, and it is almost impossible to do any thing with it.

Total Solids. Five cubic centimetres were poured into a tared platinum dish and weighed: this latter precaution is necessary, for a pipette cannot be relied upon to always deliver the same quantity of milk, as it will deliver more than enough of a poor milk and not enough of a rich one. This was evaporated to dryness on a water bath, and then dried for an hour in an oven at the temperature of 105° C. I found that treated in this way the weight became constant at the end of two and a half to three hours from the time the milk was placed on the bath.

The dishes used have a considerable influence over this result. The size I found to work best were about 65 mm. in diameter and 15 mm. in depth, with the bottom almost perfectly flat, the sides being nearly perpendicular, the angle between the sides and the bottom being rounded. Five centimetres form a layer over the bottom of this dish but little more than 2 mm. thick. When dry, it does not greatly exceed one-eighth of this amount, and thus forms a film that is very readily dried.

Fat. After weighing, the dried film is treated with either benzine or ether, which in the course of an hour or two completely removes all the fat; the benzine is decanted, a fresh portion poured on and allowed to stand half an hour; this is poured off, the dish rinsed with a little fresh benzine, allowed to stand a few minutes until it has all evaporated, again dried in the air bath at 105°, and weighed; the loss gives the fat. The residue remaining on the dish is of course the *solids not fat.*

Ash. The dish is then ignited over a Bunsen burner, and again weighed, the residue in this case being the ash. With a dish of the size spoken of, all the carbon burns off quickly and readily, and leaves the ash perfectly white.

The above determinations are all that are essential to determine the purity of a sample of milk, and, as will be seen, consume but little over 100 cc. of milk: 150 cc. are ample for the full analysis as followed. In order to determine the cheese and sugar, 25 cc. of milk were taken and diluted with about 50 cc. of water, the mixture was gently warmed, and a drop or two of acetic acid added with gentle stirring; it was allowed to cool and then filtered on a weighed filter, and washed with about 200 cc. of cold water. The filtrate was made up to 500 cc., and this solution was titrated with a normal solution of cupric sulphate made by dissolving 34.65 grammes of crystallized cupric sulphate in 200 cc. of water, adding to this solution a solution made by dissolving 173 grammes of sodio-potassic tartrate in 480 cc. of caustic soda solution of 1.14 specific gravity. The whole is then made up to a litre; 10 cc. of this solution were then placed in a flask diluted with 40 cc. of water, and brought to the boiling point; the diluted whey was then allowed to flow into the solution until it no longer gave a brown color, when filtered, acidified with acetic acid and tested with potassic ferrocyanide. The following table gives the per cent of milk sugar, when 25 cc. of the milk are taken, and the whey diluted to 500 cc. 10 cc. of the copper solution, which equals .067 grammes of milk sugar, are employed.

PER CENT OF SUGAR.

CC. of whey used.	0	1	2	3	4	5	6	7	8	9
10	13 40	12.17	11 17	10.30	9 57	8.92	8 38	7.91	7.44	7.05
20	6.70	6.39	6.09	5 83	5 58	5 36	5.15	4 96	4.78	4.62
30	4.46	4 32	4.19	4.06	3.94	3.83	3 72	3.62	3 53	3.44
40	3.35	3.27	3.19	3.11	3 04	2.98	2.91	2 85	2.79	2 74
50	2.68	2.63	2 58	2.53	2 48	2.44	2.39	2.35	2 31	2.27
60	2.23	2.19	2.16	2.13	2.09	2.06	2.03	2.00	1.97	1.94
70	1 91	1 88	1.86	1.84	1.81	1.79	1.76	1.74	1.72	1.69
80	1.67	1.65	1 63	1.61	1.59	1.57	1.56	1.54	1.52	1.51
90	1.49	1 47	1 46	1.44	1.43	1.41	1.89	1.38	1.37	1.35
100	1.34	1.32	1.31	1.30	1.29	1.28	1 26	1.25	1.24	1.23

The curd remaining on the filter is removed from the funnel and placed on a watch glass, dried at 105°, and weighed ; it is then treated with benzine in a funnel which has a stopper in it, and is covered with a tight fitting watch glass; one or two soakings serve to completely remove the fat. It is again dried and weighed. I have not as a rule found this determination of fat very satisfactory; it is apt to be too high, from the great difficulty of drying the greasy curd and filter; after the fat is removed, the caseine is very easily dried. The object in this set of analysis being rather to endeavor to find a series of constants which might be relied upon for determining the question of adulteration, no further examination of the caseine was made for ash, but the portion remaining on the filter after the removal of the fat was regarded as pure caseine. In all my determinations, I found that there was invariably a discrepancy between the sums of the caseine, fat, sugar, and ash, and the total solids as determined by evaporation. This varied from .43 per cent to 1.92 per cent, with an average of .87 ; this is owing most likely to the albumen of the milk in part, which is not precipitated by the acetic acid at 45°–50° C., and in part to the solubility of the caseine in acetic acid. As will be seen from the table annexed, the sugar seems to be the most constant constituent. The fat varies very much ; the specific gravity is not to be relied upon. Wanklin's test of solids not fat is departed from in a number of instances, and the total solids fall as low as 11.64, while according to the English authorities they should never in pure milk be below 9 per cent for the solids not fat, and 12 per cent for total solids.

In summing up, I must call attention to the remarkably high average of this milk, 14.49 per cent of total solids, but .06 short of Professor Babcock's result, with three times the number of specimens which he examined. For purposes of comparison, I annex two other tables, one giving all the average results I have been able to collect up to the present time, and the other giving the extreme variations that have been observed.

SPECIMENS EXAMINED.

A. Milk supplied me by a resident of Cambridge, said to be pure Alderney.

B. Milk from an Alderney cow kept by Dr. James R. Nichols for the supply of his family.

C. Grade cow, Herford and Ayrshire. Four years old, had been milking twelve weeks and gave sixteen quarts per day. Feed, two quarts corn meal and four quarts shorts, with all the upland hay she would eat.

D. Native cow, eight years old, had been milking three weeks, and gave eighteen quarts per day. Feed, three quarts of corn meal and three quarts of shorts, with hay; same as C.

E. Native cow, four years old, had been milking fourteen weeks, and gave eight quarts milk per day. Feed, one quart meal, seven quarts shorts per day, with hay.

F. Native cow, six years old, had been milking one week, gave sixteen quarts milk per day. Feed, six quarts shorts per day, and hay.

Cows C, D, E, and F, were owned by John Steele of Stoneham, and the milk was sold.

G. Native cow, ten years old, had been milking six months, gave seven quarts per day. Feed, four quarts corn meal and meadow hay.

H. Grade cow, half native, quarter Ayrshire, quarter Jersey, had been milking fifteen months, gave eight quarts milk per day. Feed, four quarts of corn meal and four quarts of shorts per day, with meadow hay.

I. Native cow, four years old, had been milking twelve weeks, gave thirteen quarts of milk per day. Feed, four quarts of corn meal and eight quarts of shorts per day, and meadow hay.

J. Native cow, nine years old, had been milking seven and a half months, gave eleven quarts of milk per day. Feed, six quarts of meal and eight quarts of shorts and meadow hay.

K. Native cow, nine years old, had been milking four months, gave fourteen quarts of milk per day. Feed, four quarts of meal and eight quarts of shorts and meadow hay.

L. Native cow, five years old, had been milking five and one half months, gave eleven quarts of milk per day. Feed, four quarts of corn meal and eight quarts of shorts per day, and meadow hay.

M. Native cow, seven years old, had been milking four months, gave fourteen quarts of milk per day. Feed, five quarts of corn meal and eight quarts of shorts per day, and meadow hay.

N. Grade cow, half native, half Dutch, three years old, had been milking two weeks, gave fourteen quarts of milk per day. Feed, two quarts meal, four quarts of shorts, and grass.

Cows G to N were owned by Frank Steele of Stoneham, and the milk was sold.

O. Native cow, five years old, had been milking ten weeks, gave five quarts of milk per day. Feed, one and a half quarts of meal per day and hay. The first sample of this cow's milk procured was of such an extraordinary character that two other samples were afterwards obtained: these did not equal the first, but were rather better than the average. The cow had been turned out to grass before the second was obtained. She was owned by William Buckman of Stoneham, and the milk was used at home.

P. Native cow, eight years old, gave twelve quarts of milk per day. Feed, one quart of meal, grass and hay. Owned by C. S. Wiley.

Q. Grade cow, native and Devon, nine years old, had been milking seven weeks, gave nine quarts of milk per day. Feed, grass and hay. Owned by C. Wiley. A second sample of this milk was obtained a few days afterwards: it had improved somewhat. The cow had been kept in poor condition all winter, and had not had grass long enough at the time of the first trial to feel its beneficial effects. The milk was used at home.

R. Native cow, eight years old, milking one week, gave sixteen quarts of milk per day. Feed, two quarts of shorts and grass.

S. Jersey cow, five years old, milking six months, gave eight quarts of milk per day. Feed, one quart of meal and four quarts of shorts.

R and S were owned by E. Thorpe of Stoneham, and the milk was sold.

Cow.	Sp. Gr.			Cream val. per cent.	Ash.	Caseine	Sugar.	Fat.	Total solids.	Solids not fat.	Water.
	Whole milk.	Skim milk.	Whey.								
A	1.030			16	.63				13.66		86.34
B	1.031			18	.65	3.40	5.29	6.62	15.96	9 34	84.04
C	1.033	1.031		6.5	.63	2.98	5.40	4.07	14.13	10.06	85.87
D	1 033	1.034	1.030	11	.72	3.01	5.19	4.10	13 87	9.77	86 13
E	1.031	1 030	1.029	9	.65	3.50	4 81	4.41	13.98	9 57	86.02
F	1.027	1.035	1.028	12	.67	3.38	4 47	6.01	14.99	8.98	85.01
G	1 033			9	.71	4 00	4 99	3.95	15.37	11.42	84.63
H	1.031	1.035	1 031	11	.79	5.23	4.80	4.36	15.61	11.25	84.39
I	1.031	1.034	1.030	7	.64	3.46	4.64	4 23	14.18	9.85	85 82
J	1.032	1.034	1.029	12	.74	4.49	4.63	5.95	16.26	10.31	83.74
K	1.029	1.030	1.028	9	.59	3.21	4.82	5.71	14.95	9 24	85.05
L	1.033	1.033	1.030	10	.64	3 00	4.80	4.04	14.05	10 01	85.95
M	1.030	1.029	1.028	4	.60	3 59	4.81	3 07	12.63	9.56	87.37
N	1.028	1.032	1.029	9.5	.64			4.38	13.81	9.43	86.19
O	1.018	1.030	1.024	54	.61	2.35	5.06	11 46	19.34	7.88	80 66
	1.030	1.031	1.020	18	.65	2.91		5.09	15 11	10 02	84.89
	1.028	1 029	1.026	12	.60	2.34	5.02	6.32	14.91	8.59	85 09
P	1.028	1.031	1 028	10	.66	2.57	5.21	4.11	13.43	9.32	86 57
Q	1.028	1.028	1.025	5	.57	2.25	4.82	2.71	11.64	8.93	88.36
	1 029	1.031	1.024	5	.61	2.67	5.11	4 08	13.03	8.94	86.97
R	1.033	1.034	1.026	5.5	.71	3.66	4.73	1.61	11 94	10.33	
S	1.030	1.033	1.026	11	.74	3.58	5.11	5.69	15.88	10 19	84.12
Av'rages.	1.030	1.032	1.027	12.0 10.0	.66	3.27	4.94	4.86 4.53*	14.49	9.66	85.51
Highest.	1.033	1.035	1.031	54	.79	5.23	5.40	11.46	19 34	11.42	80.66
Lowest.	1.018	1.028	1.020	5	.57	2.25	4.47	1 61	11 64	7.88	88.36

* Omitting the 15th.

SPECIMENS OF MILK SUSPECTED TO BE ADULTERATED.

Whole milk.	Cream val. per cent.	Ash.	Caseine.	Sugar.	Fat.	Total solids.	Solids not fat.	Water.
1.028	7	.51			3.33	11.42	8.09	88.58
1.023	7	.45	2.94	3.36	2 46	9 21	6.75	90.79
1.020	6	.45	3.11	3.37	2.26	9.19	6 93	90.81
1.021	7	.40	2.77	3.00	2.00	8.17	6.17	91.83

The last four specimens were all retailed by milk dealers in the vicinity of Boston, and well serve to indicate the danger of relying on any single determination for deciding whether a milk is adulterated or not. Taking all the determinations as they stand, they leave no doubt as to the fact that the milk has been watered, yet any one determination taken separately might be successfully disputed.

The following table, recently compiled by myself from various sources, is of considerable interest in this connection, as showing the great variation in this most important product. It will be observed that the specimens from this vicinity head the list, while those reported by Mr. Vaughan of Providence, R. I., are not far behind. I think that this in part may be owing to the use of corn meal as feed, since this substance is well known as a butter or fat producer.

		No. of specimens.	Solids.	Not fat.	Caseine.	Ash.
J. F. Babcock . .	Boston	8	14.55			.88
S. P. Sharples . . .	Boston	22	14.49	9.61	4.13	.66
Vernois & Becquerel	France	46	14.24	9.73	4.86	.65
Goppelstoder . . .	Switzerland	60	14.13			
H. W. Vaughan . .	Rhode Island	58	14.08	10.07	4.99	.75
Lebert.	France		14.00	9.75	5.50	.75
Letheby	England		14 00	10.10	4.10	.80
Playfair	Scotland	9	13.49	8.61	4.17	.55
Phipson	England		13.33	8.46	3.76	
Chevalier	France	2	13.23	10.31	3.98	.78
Wanklin.	England	3	13.12	9.36	4.56	.72
Cameron	Ireland	40	13.00	9.00	4.10	
Chevalier & Henry .	France		12.98	9.75	4.48	.60
A. Muller	Sweden		12.85	9.43	3.42	.72
Boussingalt. . . .	France	9	12.71	8.80	3.47	.25
Haiden			12.70	9.70	4.82	.49
Chandler.	New York	1700 qts.	12.55	8.72	3.88	.76
MacAdam	England	66	12.27	9.69		.71
Voelcker.	England	22	12.10	9.15	2.93	.83
Von Baumhauer. .	Holland	162	11.30	8.45		.72

The limits of variation as observed by some of the above observers were as follows: —

	Total Solids.		Solids not Fat.	
	Highest.	Lowest.	Highest.	Lowest.
Dr. Voelcker . .	14.00	9.30	9.88	7.51
Dr. MacAdam .	15.54	10.57	11.23	8.74
Von Baumhauer .	13.23	10.18	8.93	8.08
Vernois & Becquerel	19.68	11.70	10.56	7.73
Vaughan	16.96	12.85	11.14	8.79
Sharples	19.34	11.64	11.42	7.88

It should be remarked, in this connection, that Dr. Voelcker's results should be received with a good deal of caution, since he acknowledges the cows were half starved; and, further, he refuses to give the methods employed in his analyses. Von Baumhauer, on the other hand, has given the fullest information in regard to the methods he employed, the feed of the cows, time milking, &c.

The benzine used was the ordinary commercial article distilled from Pennsylvania petroleum of a specific gravity of about 70° B. Gasoline of the specific gravity of 90° B. was at first used; but it was found on trial that the heavier article was just as efficient in removing the fat, and that it left no residue on evaporation, while it was much safer to have in the laboratory.